CEBAF EXPERIMENT 93-043

Measurement of the ΔΔ Component in the Deuteron by
Exclusive Quasi-elastic Electron Scattering

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Excited baryons must make a contribution to the ground-state wave function of nuclei. In fact, virtual excitation of the Δ is believed to dominate the three-body interaction. No direct observation of these components has yet been made, however. This is largely because of the difficulty of cleanly distinguishing interactions on pre-existing baryons from the excitation of resonances by the probe's interaction with the target.

The deuteron is unique in that isospin conservation forbids the contribution of a single Δ excitation. The lightest Δ excitation which may appear in the deuteron wave function is the ΔΔ state. This offers the potential for a clean experimental signature based on the observation of a non-interacting spectator Δ resulting from a high momentum transfer interaction of the probe with the other Δ. The large acceptance of the CLAS spectrometer will permit the acquisition of a large set of kinematically complete events of this nature. Large statistics will permit us to impose tight cuts to eliminate many of those sources of background which limited the sensitivity of previous experiments.

The simplicity of the deuteron also makes calculations more tractable than for other nuclei. A number of authors have made predictions of the contribution of the ΔΔ component to the ground state. The variation among these models is only moderate, with $P_{\Delta\Delta}$ ranging from 0.25% to 1.2%. Although the Δ component of the deuteron has not yet been observed experimentally, there is substantial agreement not only on its existence, but on its expected magnitude.

Clearly there is great Physics interest in a direct experimental verification of the existence of non-nucleonic components in the ground state wave unction of a nucleus. On the one hand, it may be viewed as inevitable that any channel which couples strongly to the nucleonic states must make a contribution to the eigenstates of the strong Hamiltonian. On the other hand, no experiment has yet directly confirmed the existence of any such components. If sensitive experiments do not verify the expected contributions of components such as ΔΔ, they will call into question the legitimacy of baryonic states as the basis for expansion of hadronic configurations in nuclei.

One of the unique advantages offered by the deuteron is the ability to tag interactions which occur on a pre-existing Δ. The observation of a Δ spectator may be used to isolate those events for which the target was a Δ. Thus it may be possible to directly map the elastic form-factors of the bound D, providing a new insight into short-range baryon interactions.

If the spectator approximation can be justified, for some subset of the kinematics, then the momentum distribution of the pre-existing Δ's in the deuteron can be determined directly from the measurements.

We will study the Δ-Δ++ component of the deuteron by scattering electrons quasi-elastically from the Δ-. Observation of the decay of the spectator Δ++ and the scattered electron will allow selection of those events for which the unobserved hadrons have a missing mass in the Δ- region. The Δ++Δ- channel is chosen because the Δ++ decays almost 100% to two charged tracks making unambiguous reconstruction of back angle Δ++'s possible. Of these d(e,e'p π+)Δ- events, a sub-sample will also include detection of the π- from the Δ- decay, allowing reconstruction of the neutron mass as a double check that the final state includes only Δ++ and Δ-.

The goal for sensitivity of this experiment will be the ability to detect the DD component even if its contribution to the deuteron wave-function is $P_{\Delta\Delta} \approx 0.1\%$. The dominant background in most previous experiments can be seen to result from accidental combinations of a spectator proton with a pion originating from the probe-neutron interaction. That background will be eliminated in this experiment by requiring a minimum for the proton which is beyond the range expected for spectator nucleons. The angular distribution of D's originating from final state interactions may be expected to be more forward-peaked than true spectators. Therefore, angular cuts will also be important in selecting events of interest and rejecting final state interactions.